and freezing temperatures, while the older and more matured plants were badly injured, irrespective of the surroundings. Mr. E. Ravanel, who is probably one of the oldest planters in old St. Andrew's parish, has given much attention to the effects of frost upon young and tender vegetables. This gentleman's experience dates from the days of old-style farming, when fertilizers were not in such frequent use. The gentleman stated that he has known whole rows of vegetables to be burnt badly when other rows of the same kind were unscathed and recalled many such cases.

The spring of 1899, while not particularly devoid of low frost temperatures, remained mild up to and including April 20. On April 5, 1899, a heavy frost formed which almost created a financial panic among the farming community. Although advised of the approach of frosts, yet the means and methods of protection against frost have been so expensive to the farmer in late years as to preclude the idea of any further investments for this purpose, consequently the destruction of the crops was widespread. Entire fields were completely annihiliated. Replanting was resorted to and begun immediately, creating such a demand for labor as was scarcely ever equaled before in this section. The crops of the second planting were marketed somewhat earlier than those of the North Carolina and Virginia raisings, and in consequence there was a greater demand, and correspondingly advanced prices prevailed. The frosts subsequent to April 5 were pronounced mild types, and did not materially lessen the yield. In connection with the frequent occurrence of frosts during the spring of 1899 it may be remarked that as the subject was more generally discussed among the planters of St. Andrew's and Christ Church parishes, on Charleston Neck, James Island, Wadmalaw Island, Youngs Island, and Edisto Island, S. C., it followed that cases in which frost spots formed and alternate plants burnt were more numerously observed. On March 30 and April 10 and 11 there were especial marked characteristics. The writer observed the following somewhat curious phenomenon. It may at first be necessary to describe the conditions under which these frosts formed in order to more fully understand the matter. The light frost of March 30, 1899, was attended by a minimum temperature of 47°, the wind was from the north, and the velocity 5 miles per hour; April 10, 43° north, 14; April 11, 45° northwest, 5.

On March 30 the garden truck belonging to Mr. E. Ravenel, such as peas, potatoes, asparagus, and beans was well out of ground. This farm lies almost level; it is almost entirely surrounded by large forests of native pine, on the western, northern, and eastern sides, with a clean sweep of open country to the southward for one and a half miles. During the frost of March 30, 1899, and in the fields of peas, could be seen in all directions that well known droop among single plants, indicative of frost formation, while, in the same directions, could be seen healthy plants without blemishes of any kind in large numbers. The frost seemingly had formed in circular spots over this as well as over the fields of asparagus, potatoes, and beans. There is another peculiarity in frost formation not previously described, and that is its damaging effect on the asparagus plant. When nipped by frost this plant does in reality turn very black. In cutting open one of these succulent vegetables it was found that the outer shell or skin had undergone some chemical change unknown to the writer. The inner portion, or meat of the plant, was decidedly soft and stringy and the liquid could be squeezed therefrom as if out of a sponge. The general characteristics of the frosts of April 10 and 11 were much the same as those of the frost of March 30.

The spring and autumn of 1900 were fraught with many disasters among the truck farms of this locality; frosts were more frequent than for many years previous thereto and the phenomena noted in this article were frequently seen. The frosts of April 5 and November 9, 1900, were quite destructive in their effects. The writer visited the plantations of Mr. W. F. Kracke and Mr. James D. Croghan, in old St. Andrew's parish, and those of Mr. Robert Nix, Henry D. Williams, and J. S. Horlbeck, in Christ Church parish, at Mount Pleasant, S. C., a suburb of Charleston, and verified the same effects of frost during the spring and autumn of 1901 and the spring of 1902. The truck growers of this locality have become somewhat ingenious. They plant peas and cantaloupes side by side in alternate rows and three feet apart within the same field. In the event of either of the plants becoming badly injured that particular row is turned over by the plow and planting is begun over again within a few inches to the right or left of the rows that were destroyed or injured.

In seeking the cause of the irregular effects of frost formation, some attribute these injuries to the excessive use of fertilizers, and others to the ground water that elevates the temperature of the surface and prevents rapid radiation from the vegetation. The former view is untenable since all lands are covered with fertilizers evenly and alike according to the desired strength required, and it would be an almost physical impossibility to distribute the fertilizers otherwise. With respect to the ground-water theory there can be but one answer. It is known that plants near large bodies of water suffer from frost less than those located over level and dry land. Assuming then that moist air or soil is a better preventative against frost than drier air or soil, something can be said in favor of the ground-water theory. But upon further examination it is found that the lands upon which this peculiar local frost formation took place appeared equally dry or moist for a few feet below, agreeing precisely with climatic conditions. Again, local currents of air, somewhat warmer and more moist than the surrounding bodies of air, may have served to check frost formation to a limited extent and thus caused less damage than at points where the colder air settled. There is a bare possibility that the salt in the air of this section may have had some influence upon the vegetation, thus preventing a deposit of frost upon it. It is known that objects coated with salt require lower temperatures for congelation than those not so coated.

HAWAIIAN CLIMATOLOGICAL DATA.

By CURTIS J. LYONS, Territorial Meteorologist.

GENERAL SUMMARY FOR OCTOBER, 1902.

Honolulu.—Temperature mean for the month, 75.8°; normal, 76.4°; average daily maximum, 81.8°; average daily minimum, 70.3°; mean daily range, 11.5°; greatest daily range, 17°; least daily range, 6°; highest temperature, 84°; lowest, 67°.

Barometer average, 29.969; normal, 29.967; highest, 30.10, 15th; lowest, 29.84, 6th; greatest 24-hour change, that is, from any given hour on one day to the same hour on the next, .07; lows passed this point on the 6th and 25th; highs on the 10th and 15th. The pressure has been even through the month.

Relative humidity average, 74.5 per cent; normal, 71 per cent; mean dew-point, 66.6°; normal, 66.2°; mean absolute moisture, 7.17 grains per cubic foot; normal, 7.05 grains; dew, 11 morning.

Rainfall, 2.59 inches; normal, 2.76 inches; rain record days, 20; normal, 19; greatest rainfall in one day, 1.05, on the 15th; total at Luakaha, 13.12 inches; normal, 11.69 inches; total at Kapiolani Park, 0.73 inch; normal, 1.12 inch.

The artesian well level stood for the month without falling, 32.95 feet above mean sea level. October 31, 1901, it stood at 33.12. The average daily mean sea level for the month was 10.05 feet, the assumed annual mean being 10.00 feet above datum. For October, 1901, it was 10.37. Trade wind days, 21 (7 of north-northeast); normal 22. Average force of wind during daylight, Beaufort scale, 2.1. Average cloudiness, tenths of sky, 3.3; normal, 4.3.

Approximate percentages of district rainfall as compared

with normal: Hilo, 100 per cent; Hamakua, 115 per cent; Kohala, 155 per cent; Waimea (Hawaii), 75 per cent; Kona, 170 per cent; Kau, 70 per cent; Puna, 100 per cent; Maui, 150 per cent; Oahu, 95 per cent; Kauai, 135 per cent.

Mean temperatures: Pepeekeo, Hilo district, 100 feet elevation, mean maximum, 80.4°; mean minimum, 69.5°; Waimea, Hawaii, 2,730 elevation, 82.3° and 65.7°; Kohala, 521 elevation, 79.3° and 67.5°; Waiakoa, Kula, Maui, 2,700 elevation, 78.5° and 60.0°; Ewa Mill, 50 elevation, 84.8° and 67.5°; United States Experiment Station, Jared W. Smith, 350 elevation, 83.4° and 70.2°; W. R. Castle, 60 elevation, highest, 84°; lowest, 66°; mean, 75.2°.

Ewa Mill mean dew-point, 64.6°; mean relative humidity, 68.7 per cent; Kohala, Dr. B. D. Bond, 66° and 78 per cent.

Slight but decided earthquake felt at Honolulu, 4:31 a. m., 16th, day of lunar eclipse; same reported from Kohala, Waimea, 2 shocks, and Hilo, Pepeekeo. On the 20th, Kohala, 5:30 a. m,, 26th, Waimea, 3:05 and 11:05 p. m. Heavy swell and surf 15th, 17th, 27th, and 28th. Heavy rains, 3d, 15th, and 27th.

Heaviest 24-hour rains reported: Rhodes Gardens, 4.23 inches; Waiakea, Hilo, 3.31 inches; Luakaha, 4.00 inches, 27th; Puuohua, Hilo, 3.43 inches, 14th.

OBSERVATIONS AT HONOLULU.

The station is at 21° 18′ N., 157° 50′ W. It is the Hawaiian Weather Bureau station Punahou. (See fig. 2, No. 1, in the MONTHLY WEATHER REVIEW for July, 1902, page 365.)

Hawaiian standard time is $10^h\ 30^m$ slow of Greenwich time. Honolulu local mean time is $10^h\ 31^m$ slow of Greenwich.

The pressure is corrected for temperature and reduced to sea level, and the gravity correction, —0.06, has been applied.

The average direction and force of the wind and the average cloudiness for the whole day are given unless they have varied more than usual, in which case the extremes are given. The scale of wind force is 0 to 12, or Beaufort scale. Two directions of wind, or values of wind force, or amounts of cloudiness, connected by a dash, indicate change from one to the other.

The rainfall for twenty-four hours is measured at 9 a. m. local, or 7.31 p. m., Greenwich time, on the respective dates.

The rain gage, 8 inches in diameter, is 1 foot above ground. Thermometer, 9 feet above ground. Ground is 43 feet and the barometer 50 feet above sea level.

Meteorological Observations at Honolulu, October, 1902.

Date.	Pressure at sea level.	Temperature.		During twenty-four hours preceding 1 p. m. Greenwich time, or 1:30 a. m. Honolulu time.									Total rainfall at 9 a. m., local time.
				Temperature.		Means.		Wind.		Average cloudiness.	Sea-level pressures.		
		Dry bulb.	Wet bulb.	Maximum.	Minimum.	Dew-point.	Relative humidity.	Prevailing direction.	Force.		Maximum.	Minimum.	
	*	†	†			‡	‡						
1	29.89	72	68.5	84	70	67.0	72	ne.-n.	2-1	7-1	29.95	29.86	0.00
2	29.95	68	67.3	84	72	66.3	72	n.	1	4-2	29.98	29.87	0.00
3	29.98	75	69	84	68	68.0	79	nne.	1	3	30.02	29.93	0.13
4	29.97	75	69	83	72	66.0	67	ne.	3	3	30.03	29.94	0.02
5	29.95	69	67.7	80	73	66.0	71	ne.	3-1	7	30.04	29.95	0.11
6	29.92	68	67	83	68	68.5	82	nne.	2	3-9	30.00	29.91	0.01
7	29.89	70	68	82	67	68.3	87	ne.-sw.	1-0	8	29.94	29.84	0.03
8	29.91	72	71.5	82	67	69.0	82	s.-sw.	1-0	3	29.94	29.86	0.08
9	29.94	70	69	82	71	71.0	85	sw.	1-0	5	29.97	29.88	0.05
10	30.02	70	68.7	82	70	70.0	85	sw.	1-0	3	30.03	29.93	0.02
11	29.98	75	70	83	69	69.0	83	n.-ne.	1	6-0	30.07	29.97	0.00
12	29.94	75	70.5	84	68	67.7	73	nne.	2	1	30.04	29.94	0.21
13	29.94	76	69.5	83	71	67.0	70	ne.	3-5	2-7	29.99	29.90	0.04
14	29.95	75	69	81	72	66.7	70	nne.	5-2	7-2	29.99	29.89	0.15
15	30.05	74	67	80	72	67.3	74	ne.	3-4	7	30.06	29.96	1.05
16	30.05	74	66	79	70	62.7	67	nne.	5-0	2	30.10	30.03	0.00
17	30.02	69	64	80	73	62.0	63	ne.	3	7-2	30.09	29.99	0.01
18	29.98	73	66.5	81	68	62.3	66	nne.	3	3	30.04	29.94	0.00
19	29.99	75	67	81	73	62.0	64	ne.	3	2	30.04	29.94	0.00
20	30.03	74	68	81	74	63.3	64	ne.	3	3	30.06	29.96	0.01
21	29.97	73	67.5	80	72	64.0	66	ne.	3	4	30.06	29.97	0.00
22	29.96	71	68.5	82	72	65.5	72	ne.	3-1	3	30.02	29.91	0.00
23	29.96	68	67	83	68	67.7	78	se-ne.	1-0	6-3	30.00	29.91	0.01
24	29.96	67	66	82	68	67.7	82	sw-n.	1-0	7-1	30.00	29.91	0.01
25	29.94	69	68.5	83	67	66.3	76	s-ne.	0-2	2	30.00	29.88	0.02
26	29.93	74	69	84	67	68.0	78	se-ne.	1-2	2	29.98	29.91	0.00
27	29.99	75	71	82	72	66.5	70	ne.	3	1	30.02	29.92	0.15
28	29.97	74	70	78	72	68.7	84	nne.	4	5	30.08	29.98	0.45
29	29.94	76	71	81	72	67.7	77	ne.	4	4	30.01	29.91	0.03
30	29.94	75	68.5	81	73	67.7	74	ne.	3-4	5	29.97	29.87	0.00
31	29.95	66	65	82	73	64.5	66	nne.	3	1	30.00	29.92	0.00
Sums													2.59
Means	29.963	72.5	68.2	81.8	70.3	66.6	74.5		2-1	3.3	30.017	29.922	
Departure	+ .002					+0.4	+3.5			—1.0			—0.17

Mean temperature for October, 1902, $(6+2+9)+3=75.8$; normal is 76.4. Mean pressure for October, 1902, $(9+3)\div 2=29.969$; normal is 29.967.

* This pressure is as recorded at 1 p. m., Greenwich time. † These temperatures are observed at 6 a. m., local, or 4.31 p. m., Greenwich time. ‡ These values are the means of $(6+9+2+9)+4$. § Beaufort scale.

Rainfall data for October, 1902.

Stations.	Elevation.	Amount.	Stations.	Elevation.	Amount.
HAWAII.			**MAUI.—*Continued.***		
HILO, e. and ne.	*Feet.*	*Inches.*		*Feet.*	*Inches.*
Waiakea	50	12.37	Paia	180	2.15
Hilo (town)	100	12.12	Haleakala Ranch	2,000	4.00
Kaumana	1,250	.....	Wailuku, ne	200	0.94
Pepeekeo	100	11.52	**OAHU.**		
Hakalau	200	12.13	Punahou (W. B.), sw	47	2.59
Honohina	300	12.94	Kulaokahua (Castle), sw	50	2.16
Punohua	1,050	18.98	Makiki Reservoir	120	2.96
Laupahoehoe	500	11.78	U. S. Naval Station, sw	6	1.56
Ookala	400	10.14	Kapiolani Park, sw	10	0.73
HAMAKUA, ne.			Manoa (Woodlawn Dairy), c	285	11.75
Kukaiau	250	6.95	Manoa (Rhodes Gardens)	300	15.46
Paauilo	750	6.26	School street (Bishop), sw	50	2.95
Paauhau (Mill)	300	4.62	Insane Asylum, sw	30	2.15
Honokaa (Muir)	425	4.75	Kalihi-Uka, sw	450	9.13
Honokaa (Meinicke)	1,100	5.93	Nuuanu (W. W. Hall), sw	50	3.04
Kukuihaele	700	5.49	Nuuanu (Wyllie street)	250	5.12
KOHALA, n.			Nuuanu (Elec. Station), sw	405	5.85
Niulii	200	5.83	Nuuanu (Luakaha), c	850	13.12
Kohala (Mission)	521	5.93	Waimanalo, ne	25	2.69
Kohala (Sugar Co.)	235	5.98	Maunawili, ne	300	5.42
Puakea Ranch	.....	3.29	Kaneohe	100	4.31
Hawi	600	1.54	Ahuimanu, ne	350	5.75
Puuhue Ranch	.....	2.37	Kahuku, n	25	3.22
Waimea	2,720	.....	Wahiawa	900	0.79
KONA, w.			Ewa Plantation, s	60	1.64
Kailua	950	.....	Waipahu	200	0.65
Holualoa	1,350	9.03	Moanalua	15	1.83
Kealakekua	1,580	11.20	U. S. Magnetic Station	50	1.35
Napoopoo	25	5.90	Tantalus Heights	1,360	11.99
KAU, se.			U. S. Experiment Station	350	3.81
Kahuku Ranch	1,680	2.87	Upper U. S. Exp. Sta. (Castle)	1,150	10.56
Honuapo	15	1.38	**KAUAI.**		
Naalehu	650	2.17	Lihue (Grove Farm), e	200	5.06
Hilea	310	0.60	Lihue (Molokoa), e	300	4.92
Pahala	850	1.72	Lihue (Kukaua), e	1,000	12.53
Moaula	1,700	.....	Kealia, e	15	3.96
PUNA, e.			Kilauea, ne	325	7.19
Volcano House	4,000	3.18	Hanalei, n	10	9.32
Olaa, Mountain View (Russel)	1,690	11.36	Waioli	10	7.40
Kapoho	110	8.63	Waiawa	32	.....
MAUI.			Eleele	200	.....
Lahaina	.....	.....	Wahiawa	2,100	.....
Waiopae Ranch	700	0.62	Lawai	200	5.37
Kaupo (Mokulau), s	285	.....	*Delayed September reports.*		
Kipahulu, s	800	.....	Kaumana	.....	.....
Nahiku, ne	60	.....	Waiopae Ranch (Maui)	.....	1.98
Nahiku	800	.....	Haleakala Ranch (Maui)	.....	3.08
Haiku, n	700	6.32	Wahiawa (Oahu)	.....	2.63
Kula (Waiakoa), n	2,700	1.68	Waiawa (Kauai)	.....	0.00
Kula (Erehwon), n	4,500	2.31	Wahiawa Mt., s (Kauai)	.....	10.20
Puuomalei, n	1,400	6.16			

NOTE.—The letters n, s, e, w, and c show the exposure of the station relative to the winds.

CLIMATOLOGY OF COSTA RICA.

Communicated by H. PITTIER, Director, Physical Geographic Institute.

[For tables see the last page of this REVIEW preceding the charts.]

Notes on earthquakes.—October 9, slight shock at $4^h\ 6^m$ p. m., duration 2 seconds. October 13, medium shock at $4^h\ 29^m$ a. m., duration 9 seconds. October 14, slight shock at $5^h\ 49^m$ a. m., duration 7 seconds. October 15, slight shock at $2^h\ 10^m$ a. m., duration 5 seconds.

CYCLES OF PRECIPITATION.

By L. H. MURDOCH, Section Director, Salt Lake City, Utah, dated October 20, 1902.

In Utah a cycle of unusually heavy precipitation began in 1866 and continued until 1886. During that period the old settlers confidently asserted that the climate had changed to wetter and even men of scientific training tried to explain the increased precipitation as due to human agencies. It was stated that the humidity had been greatly increased by breaking up the land, irrigation, increased vegetation, etc. Since 1887 the precipitation has been deficient and nothing is now heard on the subject of human agencies increasing the humidity. Most men who spent their youth here between 1866 and 1886 will now tell you that the climate has changed to drier.

It is, therefore, evident that the person who forms the opinion that climate is changing, based upon his own personal experience, is very likely to be mistaken. And yet no one who has stood near Salt Lake City and observed on the mountain sides the shore lines of the ancient Lake Bonneville can doubt for a